# CS575 Parallel Computing Project#4
# Functional Decomposition

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## 1.

What your own-choice quantity was and how it fits into the simulation.

I added agent Wolf. The interaction between wolf & deer, and deer & grain is:

- when #wolf is less or equal to (#Deer - 2), wolf will increase by 1, I assume wolf tries to be smart. They always strive to increase the population whenever they have chances, but there must be deer they cannot catch, if they count on the exact number to increase the population, they will be in danger.
- when wolf is more than (#Deer - 4), wolf will decrease by 1 since they are starving. I assume there turned out to have more smart deer that always will escape from the wolf.
- when #Deer $<$ (GrainHeight - 5), they keep increasing the population by 10 each time. But due to the existence of the wolf, they have also decrease by #Wolf * 0.1.
- when #Deer $>=$ (GrainHeight -5), deer will decrease by 5, because some deer (i.e., 5) may have a territory that not all of them have access to. Similarly, they will decrease the population by Wolf * 0.1.

I also changed initial condition to NowNumDeer = 20, NowHeight = 20., NowNumWolf = 1.

## 2.

A table showing values for temperature, precipitation, number of graindeer, height of the grain, and your own-choice quantity as a function of month number.

**Table 1. Simulation Performance**

| Year | Month | Temperature (°C) | Precipitation (Inch) | Grain Height (Inch) | Deer | Wolf |
|---|---|---|---|---|---|---|
| 2017 | 0 | 20.69 | 8.75 | 10.24 | 14 | 2 |
| 2017 | 1 | 25.87 | 11.44 | 4.57 | 8 | 3 |
| 2017 | 2 | 51.52 | 10.22 | 3.22 | 2 | 4 |
| 2017 | 3 | 60.45 | 12.33 | 2.36 | 0 | 3 |
| 2017 | 4 | 62.7 | 12.24 | 2.42 | 0 | 2 |
| 2017 | 5 | 72.76 | 6.89 | 2.42 | 0 | 1 |
| 2017 | 6 | 64.34 | 4.68 | 2.44 | 0 | 0 |
| 2017 | 7 | 59.01 | 1.1 | 2.56 | 0 | 0 |
| 2017 | 8 | 56.05 | 0 | 2.84 | 0 | 0 |

**Table 2. Simulation Performance (continue)**

| Year | Month | Temperature(°C) | Precipitation (Inch) | Grain Height (Inch) | Deer | Wolf |
|---|---|---|---|---|---|---|
| 2017 | 9 | 50.53 | 0 | 4.05 | 0 | 0 |
| 2017 | 10 | 31.03 | 3.61 | 7.03 | 0 | 0 |
| 2017 | 11 | 37.86 | 3.05 | 12.93 | 10 | 0 |
| 2018 | 0 | 37.13 | 6.57 | 16.11 | 5 | 1 |
| 2018 | 1 | 45.11 | 12.04 | 21 | 14 | 2 |
| 2018 | 2 | 42.11 | 13.71 | 22.34 | 23 | 3 |
| 2018 | 3 | 63.75 | 13.23 | 10.87 | 17 | 4 |
| 2018 | 4 | 72.39 | 11.69 | 2.37 | 11 | 5 |
| 2018 | 5 | 70.23 | 9.45 | 0 | 5 | 6 |
| 2018 | 6 | 60.5 | 2.76 | 0 | 0 | 5 |
| 2018 | 7 | 72.02 | 1.79 | 0 | 0 | 4 |
| 2018 | 8 | 57.16 | 0 | 0.19 | 0 | 3 |
| 2018 | 9 | 52.89 | 0.48 | 0.96 | 0 | 2 |
| 2018 | 10 | 38.44 | 2.23 | 6.3 | 0 | 1 |
| 2018 | 11 | 33.28 | 6.38 | 11.88 | 9 | 0 |
| 2019 | 0 | 33.11 | 6.62 | 12.93 | 4 | 1 |
| 2019 | 1 | 40.82 | 11.23 | 20.72 | 13 | 2 |
| 2019 | 2 | 54.14 | 13.39 | 15.42 | 22 | 3 |
| 2019 | 3 | 60.45 | 12.04 | 4.57 | 16 | 4 |
| 2019 | 4 | 63.74 | 10.96 | 0 | 10 | 5 |
| 2019 | 5 | 68.23 | 9.34 | 0 | 4 | 6 |
| 2019 | 6 | 67 | 3.35 | 0 | 0 | 5 |
| 2019 | 7 | 73.72 | 1.68 | 0 | 0 | 4 |
| 2019 | 8 | 50.22 | 0 | 1.29 | 0 | 3 |
| 2019 | 9 | 41.41 | 0.59 | 5.34 | 0 | 2 |
| 2019 | 10 | 34.39 | 3.64 | 10.21 | 9 | 1 |
| 2019 | 11 | 27.38 | 4.45 | 7.21 | 3 | 2 |
| 2020 | 0 | 28.76 | 7.6 | 8.37 | 0 | 1 |
| 2020 | 1 | 26.07 | 10.95 | 9.79 | 9 | 0 |
| 2020 | 2 | 48.54 | 12.36 | 9.86 | 4 | 1 |
| 2020 | 3 | 56.69 | 11.67 | 8.46 | 13 | 2 |
| 2020 | 4 | 66.21 | 10.09 | 1.97 | 7 | 3 |
| 2020 | 5 | 73.19 | 6.69 | 0 | 1 | 4 |
| 2020 | 6 | 71.48 | 6.17 | 0 | 0 | 3 |
| 2020 | 7 | 62.98 | 3.24 | 0.03 | 0 | 2 |
| 2020 | 8 | 55.79 | 1.65 | 0.44 | 0 | 1 |
| 2020 | 9 | 44.57 | 0 | 3.43 | 0 | 0 |
| 2020 | 10 | 32.08 | 2.94 | 6.67 | 0 | 0 |
| 2020 | 11 | 40.44 | 4.08 | 13.7 | 10 | 0 |

**Table 3. Simulation Performance (continue)**

| Year | Month | Temperature (°C) | Precipitation (Inch) | Grain Height (Inch) | Deer | Wolf |
|---|---|---|---|---|---|---|
| 2021 | 0 | 34.55 | 6.33 | 15.2 | 5 | 1 |
| 2021 | 1 | 40.16 | 9.93 | 22.7 | 14 | 2 |
| 2021 | 2 | 42.72 | 11.82 | 24.68 | 23 | 3 |
| 2021 | 3 | 62.94 | 12 | 13.23 | 17 | 4 |
| 2021 | 4 | 58.9 | 10.41 | 5.01 | 11 | 5 |
| 2021 | 5 | 63.97 | 8.69 | 0 | 5 | 6 |
| 2021 | 6 | 74.4 | 5.32 | 0 | 0 | 5 |
| 2021 | 7 | 69.23 | 0.18 | 0 | 0 | 4 |
| 2021 | 8 | 60.36 | 0.78 | 0.07 | 0 | 3 |
| 2021 | 9 | 49.54 | 0.05 | 1.56 | 0 | 2 |
| 2021 | 10 | 33.67 | 1.87 | 5.02 | 0 | 1 |
| 2021 | 11 | 29.59 | 5.54 | 7.8 | 9 | 0 |
| 2022 | 0 | 23.08 | 9.41 | 3.86 | 4 | 1 |
| 2022 | 1 | 27.34 | 10.52 | 3.87 | 0 | 2 |
| 2022 | 2 | 39.39 | 11.93 | 13.47 | 0 | 1 |
| 2022 | 3 | 52.8 | 12.64 | 15.28 | 9 | 0 |
| 2022 | 4 | 59.26 | 11.28 | 11.02 | 19 | 1 |
| 2022 | 5 | 70.63 | 8.37 | 1.52 | 13 | 2 |
| 2022 | 6 | 77.71 | 6.08 | 0 | 7 | 3 |
| 2022 | 7 | 71.23 | 0.17 | 0 | 1 | 4 |
| 2022 | 8 | 65.05 | 0 | 0 | 0 | 3 |
| 2022 | 9 | 40.96 | 0.28 | 3.85 | 0 | 2 |
| 2022 | 10 | 39.17 | 1.57 | 8.74 | 0 | 1 |
| 2022 | 11 | 27.55 | 5.31 | 10.44 | 9 | 0 |

This is raw data. In the plot, the month is changed to continuous variable, and Temperature is converted to Celsius. (5./9.)*(°F-32)

## 3.

A graph showing temperature, precipitation, number of graindeer, height of the grain, and your own-choice quantity as a function of month number. Note: if you change the units to C and centimeters, the quantities might fit better on the same set of axes.

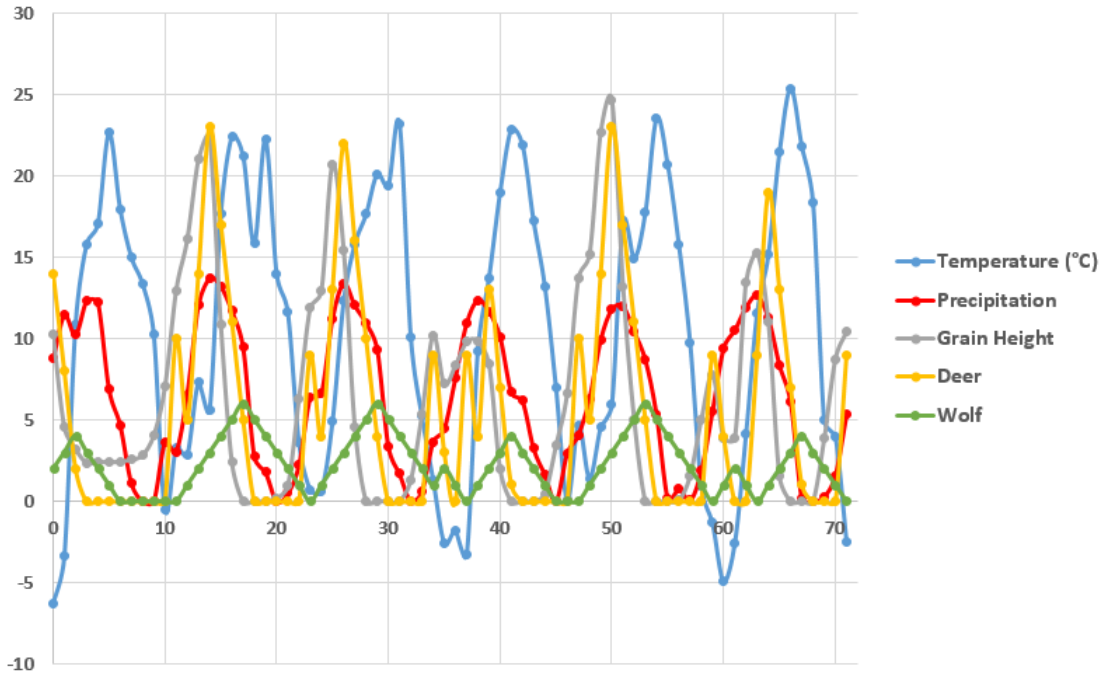


**Figure 1. Farm entities' interaction**

## 4.

A commentary about the patterns in the graph and why they turned out that way. What evidence in the curves proves that your own quantity is actually affecting the simulation?

- First, look at the number of the grain height (gray line) and deer (yellow line), the #Deer increases as the grain height increase. The deer decrease when grain height decreases. The small delay in the #Deer increase indicates the its interaction condition with grain height. This is very obvious at 4th year, the grain height is low, so does #Deer.
- Second, the simulation forced the minimum value of Deer, Wolf, Grain height, Precipitation to be 0. The increase of deer and wolf from 0 is to mimic the scenario that when the deer and wolf extinct, there are deer and wolf walk into the farm from other places.
- Third, the variation of the grain height & precipitation, and temperature are very similar. This is because their quantity are all directly related.

Since we put barriers in the sections, we are able to get the increase and decrease aligned (with small delay or jump). At each month, the temperature and precipitation lead to the interaction with grain height, deer, and wolf. That's why we are able to see the cycles on each item.

Look at the number of the Deer (yellow line) and Wolf (green line). The #Wolf changes along with #Deer, and there is delay in increase of #Deer and #Wolf. For example, the maximum value of wolf is 4 lower than the current Deer number, which corresponding to the interaction condition described in the simulation. The increase and decrease pattern are very similar. The wolf number is directly related to the deer and the variation is very liner.